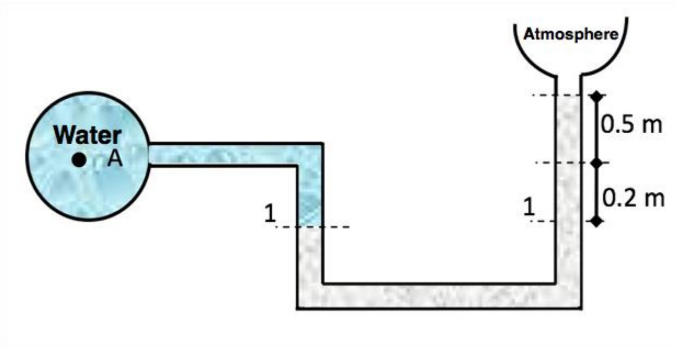
## Manometers

❖ ***Unless mentioned, the following values of fluid characteristics can be used whenever necessary in solving the questions.*** **$\gamma_{water}$=9.81 kN/ m$^3$, $\gamma_{mercury}$=133.42 kN/m$^3$ ve $p_{atm}$=98.1 kN /m$^2$.**

**Question 1**: Find the absolute and gage pressures at point A in the U manometer given below. End of the tube is open to atmosphere.



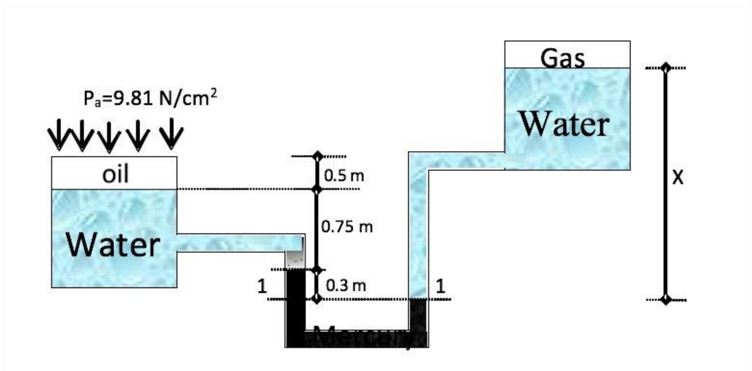

**Solution 1**:

At the cross section 1-1, the pressure is the same since the pressure at equal elevations of the same continuous mass of fluid is the same. The absolute pressure value at point A ($P_{AA}$) is:

$$P_{AA} = P_{atm} + 0.7\,x\,\gamma_{mercury} - 0.2x\,\gamma_{water} \rightarrow P_A = 98.1kN/m^2 + 0.7\,m\,x\,133.42kN/m^3 - 0.2\,m\,x\,9.81kN/m^3$$

$$P_{AA} = 189.53kN/m^2 \text{ veya } P_{AGage} = P_{AA} - P_{atm} \rightarrow P_{AGage} = 189.53 - 98.1 \rightarrow P_{AGage} = 91.43kN/m^2$$

**Question 2**: In the manometer system given below, the absolute pressure of the enclosed gas is $P_{gas}$ = 39.24 kN/m$^2$. Find the horizontal distance X. ($\gamma_{oil}$=7.85 kN/m$^3$).



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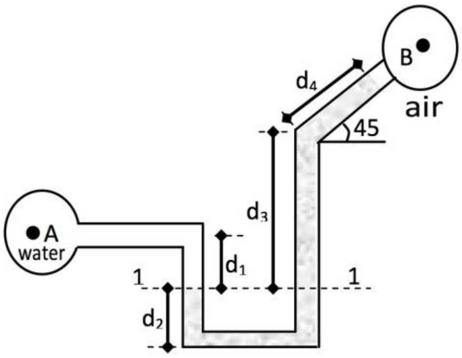
**Solution 2**: At the cross section 1-1, the pressure is the same since the pressure at equal elevations in a same continuous mass of fluid is the same.

Equality of Pressures at 1-1 level $\Rightarrow$ $p_{1Left} = p_{1Right}$

$$\left.\begin{array}{l} p_{1Left} = p_{atm} + 0.5\times\gamma_{oil} + 0.75\times\gamma_{water} + 0.3\times\gamma_{mercury} \\ p_{1Right} = X\times\gamma_{water} + P_{Gas} \end{array}\right\rangle \Rightarrow X = 2.23\,\mathrm{m}$$

**Question 3**: For the given values of $d_1$=30 cm, $d_3$=45 cm, $d_4$=20 cm, find the pressure difference between points A and B given in the drawing below.




**Solution 3**:

Equality of Pressures at 1-1 level $\Rightarrow$ $p_{1Left} = p_{2Right}$

$$p_{1Left} = p_a + d_1\times\gamma_{water}$$

$$p_{2Right} = p_b + d_3\times\gamma_{mercury} + d_4\times\sin 45^o\times\gamma_{mercury}$$

$$p_a - p_b = \gamma_{mercury}\left(d_3 + d_4\times\sin 45\right) - d_1\times\gamma_{water} \Rightarrow p_a - p_b = 75.96\,kN/m^2$$

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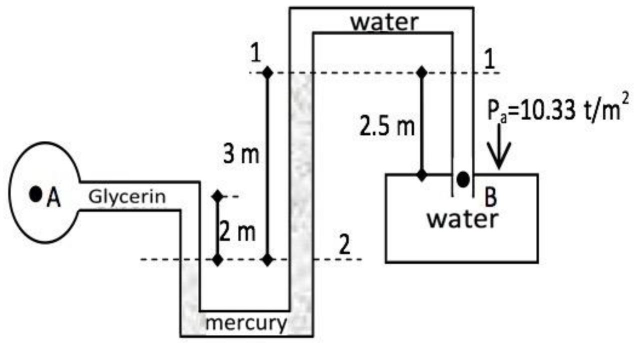
**Question 4**: Taking into consideration the manometer system shown below, find the absolute pressure at point A. ($p_{atm}$=101.34 kN/m$^2$, $\gamma_{glycerin}$=12.36 kN /m$^3$, $\gamma_{water}$=9.81kN /m$^3$)




**Solution 4**:

Pressure Equality at neo-surfaces $\Rightarrow$ $p_{1Left} = p_{1Right}$ *ve* $p_{2Left} = p_{2Right}$

$$p_{2Left} = p_A + 2\times\gamma_{\text{gliserin}} = p_A + 2\times 12.36$$

$$p_{2Right} = p_{1Left} + 3\times\gamma_{\text{mercury}} = p_{1Left} + 3\times 133.42$$

$$p_{1Right} = p_{\text{atm}} - 2.5\times\gamma_{\text{water}} = 101.34 - 2.5\times 9.81$$

$$p_A + 2\times 12.36 = 101.34 - 2.5\times 9.81 + 3\times 133.42 \quad\Rightarrow\quad p_A = 452.34 kN/\text{m}^2$$

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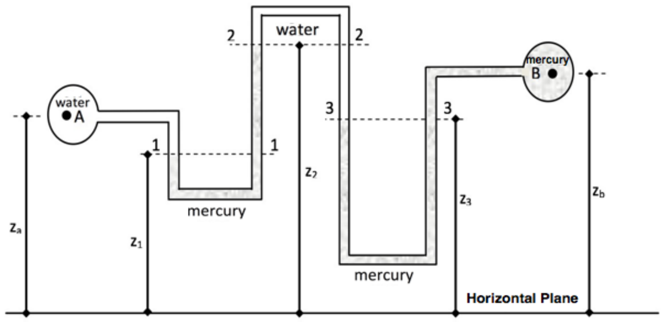
**Question 5**: Taking into consideration the manometer system shown below find the pressure difference $P_A - P_B$.

$z_a$=1.6 m, $z_1$=0.7 m, $z_2$=2.1 m, $z_3$=0.9 m, $z_b$=1.8 m

$\gamma_{mercury} = 133.42 kN/m^3$, $\gamma_{water} = 9.81 kN/m^3$.




**Solution 5**:

Pressure Equality at neo-surfaces ⇒

$$p_B = p_A + \gamma_{water}(z_a - z_1) - \gamma_{mercury}(z_2 - z_1) + \gamma_{water}(z_2 - z_3) - \gamma_{mercury}(z_b - z_3)$$

$$P_B = P_A + 9.81x(1.6-0.7) - 133.42x\,(2.1-0.7) + 9.81x(2.1-0.9) - 133.42x(1.8-0.9)$$

⇒ $p_A - p_B = 286.26$ kN/m$^2$

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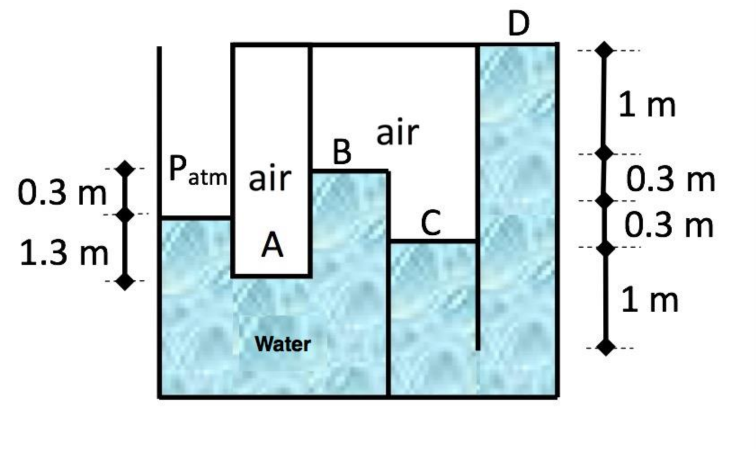
**Question 6**: Find the gage pressures at the points A, B, C and D for the composite container system given below. (The fluid is water and Specific weight of air is neglected).




**Solution 6**:

$P_{atm}$=0 is considered since we are operating with gage pressure.

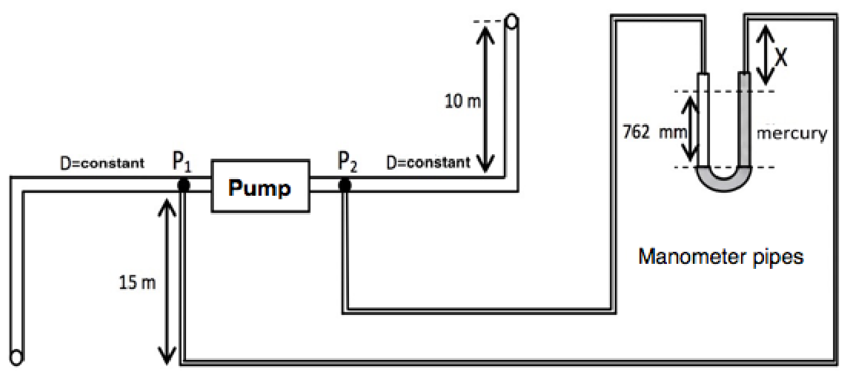
$$P_A = P_{atm} + \gamma_{water} x1.3 \rightarrow P_A = 0 + 9.81x1.3 \rightarrow P_A = 12.75 kN/m^2$$

$$P_B = P_A - \gamma_{water} x1.6 \rightarrow P_B = 1.3 - 9.81x1.6 \rightarrow P_B = -2.94 kN/m^2$$

$P_B = P_C$ (Pressure is same at every point in a closed container when at the steady state condition.)

$$P_D = P_C - \gamma_{water} x1.6 \rightarrow P_D = -0.3 - 9.81x1.6 \rightarrow P_D = -18.64 kN/m^2$$

**Question 7**: A pressure increase can be seen due to the pump in the manometer system given below. The fluid in the manometer is mercury. Other parts of the manometer are filled with water. Find the pressure difference $P_1$-$P_2$.



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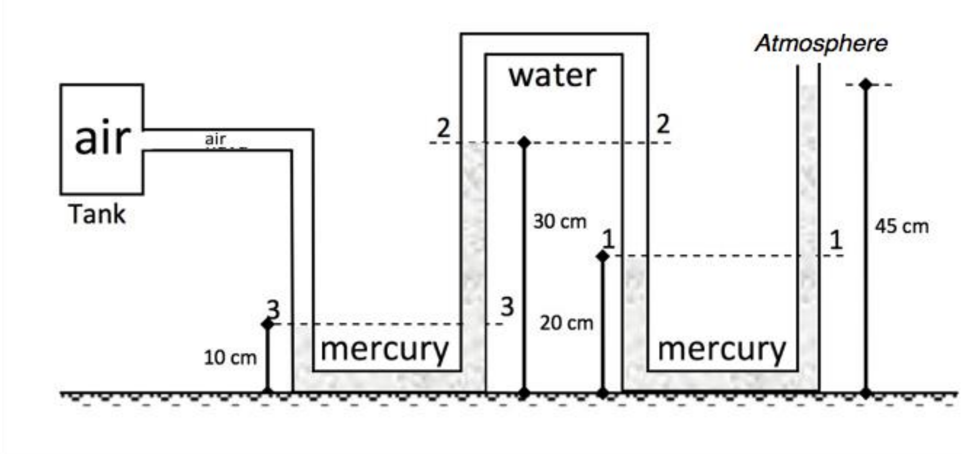
**Solution 7**:

$$P_1 - \gamma_{water} x15 - \gamma_{water} x(15+10) + \gamma_{water} X + \gamma_{mercury} x0.762 - \gamma_{water} x0.762 - \gamma_{water} X + \gamma_{water} x10 = P_2$$

$$P_1 + 9.81x15 - 9.81x25 + 133.42x0.762 - 9.81x0.762 + 9.81x10 = P_2$$

$$P_1 - P_2 = -93.88 kN/m^2$$

**Question 8**: Find the air pressure inside the tank.




**Solution 8**:

Pressure Equality at neo-surfaces ⇒ $p_{3Left} = p_{1Right}$ , $p_{2Left} = p_{2Right}$ , $p_{1Left} = p_{1Right}$

$$P_{Tank} = P_{atm} + \gamma_{mercury} x(45-20) - \gamma_{water} x(30-20) + \gamma_{mercury} x(30-10)$$

$$P_{Tank} = 10 + 133.42x0.25 - 9.81x0.10 + 133.42x0.20$$

$$(P_{Tank})_{Absolute} = 156.98 kN/m^2 \qquad (P_{Tank})_{Gage} = 58.89 kN/m^2$$